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Abstract

Word recall performance was assessed at a baseline, after working memory training expressed as a rehearsal task, and following a distraction task. Group performance indicated improvement on word recall following working memory training in relation to the baseline. Males were found to have no significant improvement in working memory performance following rehearsal, but a diminished recall performance after distraction task, like the group comparison and female comparison. The results of analysis for the female sub-group indicated results in terms of main effects identical to the group results in relation to the baseline task whereby recall after rehearsal was improved compared to baseline, while recall post distraction task was diminished.

Keywords: working memory, memory, recall, rehearsal

Working Memory: Training and Recall Performance

Memory, in terms of analysis, encoding, and recollection of information, is an especially vital part of the human capacity to exist and survive. Since the ability of the brain to manipulate information affects the very survival of the human species, it stands to reason that research is being continuously done in order to understand how memory works for the purpose of preventative health, treatment, and optimization of memory ability. Working memory, or the part of the memory process that allows the brain to encode information for later retrieval, is therefore of the greatest importance. Research is typically divided between the neurochemical aspect of brain function and the abstract or theoretical understanding of how the brain functions, with interest in the correlation between the physiological and psychological aspects of brain function. In terms of memory research, regardless of psychological specialty, recent research has taken a keener interest in working memory as it exists unto itself, as well as the impact working memory capacity has on related cognitive functions.

Working memory has been the focus of numerous studies in recent years, both in the attempt to understand exactly what working memory is and does, and to search for ways to improve working memory in neurotypical and non-neurotypical individuals. While there are numerous approaches and perspectives to working memory capacity, the underlying motivations for study of working memory remain consistent. Recent research suggests that working memory capacity is either strongly related to, or identical to, executive functioning; and that working memory training is effective only in participants that are not neurotypical (e.g. McCabe, Roediger, Macdaniel, Balota, and Hambrick, 2010; Melby-Lervåg & Hulme 2013; Redick, Shipstead, Harrison, Hicks, Fried, Hambrick,. . . Engle, 2013; Shipstead, Redick, Engle, 2012)

According to McCabe, Roediger, Macdaniel, Balota, and Hambrick (2010) both neuropsychologists and experimental psychologists acknowledge working memory capacity, but consider this concept differently depending on their specialty. For instance, McCabe, et al (2010) refer to this concept as attentional control, neuropsychologist consider this executive functioning, and experimental psychologists consider this to be working memory capacity. In this regard, the capacity for working memory has been considered of important regardless of psychological specialization, but the uses and implications vary by sub-discipline. For this reason, McCabe, et al (2010) examined the relationship between working memory capacity and executive functioning to determine the presence of either being strongly related but different concepts, or else the same concept ascribed different terminology. To this end participants in a sample of over 200 between ages of 18 and 90 were administered tests designed to measure working memory capacity and executive functioning in order to find similarities and test the strength of the relationship between these two concepts. Additionally, episodic memory and processing speed were tested to account for the influence of age on participant results. Their resulting conclusions indicated a common executive attention component between working memory capacity and executive functioning. However, the strength of the relationship was not such that these two concepts can be considered identical.

Redick, Shipstead, Harrison, Hicks, Fried, …Engle (2013) examined the effects of working memory training in terms of efficiency due to design limitations, mixed results, and lack of theoretical grounding, to use their terminology. In the course of reviewing numerous recent studies for the effectiveness of working memory training in improvement of cognitive function, the research team made the above determination, as a result choosing to conduct a randomized and placebo controlled study in order to determine the validity preexisting claims. Using a dual

n-back training for the experimental group, and an adaptive visual search program for the control group, no positive transfer was found to cognitive ability tests (Redick, et al 2013). While the researchers admit that the working memory capacity in their findings did not correlate to improved cognitive ability test performance, they also indicate that their subject basis was on the presumption of neurotypical participants. This distinction is potentially important due to the possibility that these results have weight only in terms of neurotypical adults.

This contrast is evident in the research of Melby-Lervåg & Hulme (2013), whereby their findings suggest that in the cases of children and adults with attention deficit related disorders, working memory training had a statistically significant improvement. During their meta-analytic review, cases were screened according to criteria intended to establish validity of previous research findings for the purpose of analysis. Randomized control trials and quasi-experiments without randomization that included treatments and both experimental and control groups were chosen (Melby-Lervåg & Hulme, 2013). The researchers make note that out of the twenty-three cases that were selected, there was inclusion of typically developing children and neurotypical adults within the studies analyzed. The researchers found limited evidence that children and adults with attention deficit spectrum disorders gained some benefit on cognitive performance following working memory training. However it should be noted that their findings in terms of typically developing children and neurotypical adults reach the same conclusions as the study by Redick, et al (2013), in that there was no significant evidence found for improvement for individuals who were neurotypical.

To expand upon the findings which indicate that working memory training does not improve performance of related tasks overall, Shipstead, Redick, & Engle (2012) indicate that at the point of this research accounting for errors in research design were not considered when

viewing and interpreting the results of working memory training efficiency studies. Indeed, this study drew the conclusion that a properly administered and controlled study would be necessary to determine effectiveness of working memory training, leading to the study in 2013 by Redick, et al. For the purposes of Shipstead, Redick, & Engle (2012), working memory is defined as a cognitive system that relates novel information as well as direct attention to goal-relevant information. It is this basis for definition, which was used in their subsequent study, and in the study conducted by Melby-Lervåg & Hulme, (2013). The concerns expressed by the researchers included but were not limited to improper control methods and cognitive tasks that were too similar in design to the original working memory training exercises. It was therefore felt that the basis for the findings within the reviewed studies was flawed. Giving Cogmed, a popular working memory training company, as an example, they indicate only two of the company's research ventures into the efficiency of working memory training were conducted in a manner that did not invalidate the results due to improper implementation of the respective studies.

It is for this reason, and with these previous studies in mind, that the scope of the research conducted for this experiment was to further test the validity of working memory training on working memory performance, particularly word recall. The justifications for using word recall tasks which were related to the training and distraction criteria were due to an attempt to indicate that even inside of related cognitive tasks, working memory training failed to have a significant improvement in cognitive performance. To this research, it was hypothesized that working memory training would not have a significant main effect on recollection task performance.

Methods

Participants

Participants were initially chosen based upon being of the age of consent and able to provide informed consent. This was done to allow researchers the opportunity to examine the data without excluding participants based on demographics or neurotypicality as a criterion, for the purpose of looking for trends within research results. Secondary analysis of the demographic data allowed researchers to determine that viable testing by gender was possible. Age, ethnicity, and whether the participant was a college student were demographics that were initially considered for secondary tests but ultimately were determined to be unviable due to the limitations within the demographic results for each category. In this case meaning a lack of sufficiently broad spectrum in each demographic criterion. Out of 59 participants, 52 were ages 18-21, 57 were currently attending college, 44 were female, and 42 were Caucasian. Out of the remaining numbers for the ethnic demographic, one identified as Asian, two preferred to not self-identify ethnicity, and 14 identified themselves as African American.

Materials

For this study, computers with viable internet connections were used to administer Qualtrics surveys. Additionally, results were analyzed using SPSS to analyze the data. Researchers used pen and paper when reviewing the results to make notations in demographic trends for the purpose of determining additional analyses that could be run in relation to their respective hypotheses.

Procedure

Participants were requested, after providing informed consent, to answer truthfully and to the best of their ability a series of questions intended to gauge their perception of personal memory performance. For this study, memory is operationally defined as the accurate recollection and written, or selected expression of stimuli previously viewed in the context of the survey administered. Participants self-reported demographics based on age, gender, ethnicity, and whether they were currently attending college. The choice to include analysis for each gender option of male and female was made after data was collected. The baseline recall task provided participants with a list of twenty words selected based on neither being emotionally primed not categorically related. For a duration of one minute they could view the list, after which they were allowed another minute without the list to type the words, they recalled from the word bank. The second recall task was identical with the exception that, as working memory training, participants were requested to rehearse words from the second list. Additionally, while the first- and second-word lists contained the same words, they were randomized to prevent interference from position familiarity. For the final recall task, participants were provided with a word list comprised of ten words from the prior lists and ten new words. Dr. Seuss's *Green Eggs and Ham* was displayed for one minute, after which participants were to indicate by checkmark words that appeared on the previous lists, and not check words that were not. This was done for the purpose of gauging short-term influence of both working memory training and distraction on a simple word recall task. For the baseline and second recall task, a list of words comprised of the same twenty words in different order were used, whereby after following instructions participants were asked to recall as many as possible by writing them down, with a time limit of

one minute per recall attempt. For the final recall task, a list comprised of ten of these words along with ten words that had not been used previously in which participants had a minute in order to check next to words they believed were on the initial two lists. This variability of task was included to prevent familiarity due to repeated and recent exposure.

Results

To find if there is a difference in recall performance between the baseline recall task, the second recall task, and the third recall task, a Repeated Measures ANOVA was performed on the variables Recall_Base, Recall_1, and Recall_2. Normality and sphericity were both assumed. A significant main effect was found, $F(2, 60) = 52.15$, $p < .05$. Pairwise comparisons showed multiple significant main effects. For the collective sample, the pairwise comparison tests indicated that participants had a higher recall for their baseline task than their second recall task, the latter of which was given after a working memory exercise. The second recall task had lower accuracy than either the baseline or the first recall task. The second recall task was given after participants completed a distraction task. ($M_1 = 12.1$, $SD_1 = 3.4$; $M_2 = 15.71$, $SD_2 = 2.34$; $M_3 = 10.00$, $SD_3 = 0.00$).

To find if there is a difference for males in recall performance between the baseline recall task, the second recall task, and the third recall task, a Repeated Measures ANOVA was performed on the variables Recall_Base, Recall_1, and Recall_2. Normality and sphericity were both assumed. A significant main effect was found, $F(2, 16) = 10.62$, $p < .05$. Pairwise comparisons showed significant main effects between the second and third recall task. For the exclusively male sample, the only significant main effect found was a higher accuracy on the second recall task in comparison to the third. ($M_1 = 11.89$, $SD_1 = 4.20$; $M_2 = 15.78$, $SD_2 = 2.91$; $M_3 = 10.00$, $SD_3 = 0.00$).

To find if there is a difference for females in recall performance between the baseline recall task, the second recall task, and the third recall task, a Repeated Measures ANOVA was performed on the variables Recall_Base, Recall_1, and Recall_2. Normality and sphericity were both assumed. A significant main effect was found, $F(2, 42) = 41.59$, $p < .05$. Pairwise comparisons showed multiple significant main effects. For the female sample, the pairwise comparison tests indicated that participants had a higher recall for their baseline task than their second recall task, the latter of which was given after a working memory exercise. The second recall task had lower accuracy than either the baseline or the first recall task. The second recall task was given after participants completed a distraction task. ($M_1 = 12.20$, $SD_1 = 3.13$; $M_2 = 15.68$, $SD_2 = 2.15$; $M_3 = 10.00$, $SD_3 = 0.00$).

Discussion

Summarizing Findings

Overall, improvement was found in word recall accuracy following working memory training. However, based on results, distraction tasks along with reduced working memory training resulted in a reduction of recall performance compared to both the baseline recall task and the recall task performed after working memory training. This indicates a significant benefit to working memory training in short term recall task performance in relation to reduced or non-existent working memory training. The anomaly in the test results were found in the repeated measure ANOVA run on male participants, in this a significant main effect was not found between the baseline and the first recall task. Given this is the exception compared to total sample test results and female sample test results, it is uncertain whether this is an exception present due to demographics, or a gender specific phenomenon.

General Summary

In comparison with previously conducted studies, the results for this experiment indicate a positive main effect in terms of recall performance after working memory training. Redick, et al (2013) and Shipstead, Redick & Engle (2012) both indicate both in meta-analysis of previous research and in their own research that working memory training lacks efficiency in performance of cognitive tasks. However, they set exclusion criteria including the avoidance of cognitive testing that related too strongly to the training tasks used in the attempt to improve working memory. Due to the intentional lack of this exclusion criteria in research conducted via the recall experiment, the conclusion drawn is that the results of the analysis of the word recall experiment are erroneous. Further, while Melby-Lervåg & Hulme (2013) both acknowledged and accounted for atypically developing children and non-neurotypical adults with attention deficit inhibitions of function, the word recall experiment did not take these differences into account. McCabe, et al (2010) found a strong relation between working memory capacity and executive function but were unable to determine whether they were simple related or the same concept. This finding is important not only in terms of indicating the significance of working memory capacity to researchers, but also in terms of expanding research schemes. That is, if they are strongly correlated, and possibly the same concept, then research that had traditionally been conducted for executive functioning should be reevaluated in terms of how it relates to working memory capacity, and vice versa.

Future Research

As indicated in supplementary research, conducting working memory training assessments for the purpose of effectiveness can be applied to specific incidences of participants with conditions such as attention deficit issues in order to ascertain whether these treatments provide improvement in working memory function. Further, by accounting for these factors a series of experiments can be conducted on neurotypical and non-neurotypical participants to locate differences within and without each group. This in turn could potentially find greater potential for treatments of psychological conditions in terms of attention that participants might desire improvement. Likewise, both the word recall experiment and the supportive literature have all found that in cases where the object task is related, working memory training increases performance. While this does not indicate original assumptions of a broad transference between working memory training and cognitive tasks, this does allow for intentional planning of working memory training as a basis for employee training, for instance.

Limitations

The largest limitation was due to demographic split in the participants, while searching for groups within the sample only gender was found to be viable. Additionally, markers for physical or mental health conditions that could affect results were not accounted for in the experiment. The research done by Melby-Lervåg & Hulme (2013) on the benefits of working memory training for participants with attention deficit problems brings into focus that not only the obvious demographics should be considered, but an accurate accounting should be made for factors that are psychological or physiological in nature. Likewise, even the research by Shipstead, Redick, & Engle (2012) and Redick, et al (2013) admit that working memory training where cognitive tasks used as measures indicated improvement due to similarity to training.

While this was an intentional criterion for the word recall experiment, it excluded possibility of research that accounted for this behavior as an exclusion criterion.

Applications

Due to significant main effects being found in the word recall experiment for working memory training as it applies to recall tasks that are related to the training, the most obvious indication of productive application is as a job training resource for specific tasks. Additionally, Melby-Lervåg & Hulme (2013) have indicated the improvement in individuals with attention deficit related disorders which would be a viable application, particularly in terms of mitigating issues with focusing on stimuli and repetition of skills in which individuals find difficulty due to their condition. This supposition lends itself to the measure of improvement via repetition in a limited fashion even if research suggests that the cognitive improvements are not shared across myriad tasks. During the word recall experiment a practical demonstration of the literature supporting the experiment enabled the conclusion that while the initial intentions of working memory training may be unsubstantiated, the practice itself is not without merit.

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Appendices

Informed Consent

The following survey is a survey for a learning/cognition class. The first part of this survey is designed to measure how you feel about your memory. The second part of this survey is a simple word recall task. Please be aware that questions are potentially sensitive in nature. This survey should take you 15-20 minutes to complete.   Your participation in this research study is strictly voluntary, and you may choose to withdraw from participating at any time by closing the survey or by not selecting to submit your results at the conclusion of the questionnaire. You may also decide not to answer specific questions, this is okay. However, we encourage you to complete the survey fully as it all pertains to our research.   The researchers will only have access to answers that are not personally identifiable in terms of identifying participants, the survey requests the name of each participant, and however this information will be viewable only by the instructor, Dr. MacKewn. If you have any questions, comments, or concerns, you may contact the researchers directly: Ariel Vines (ariivine@ut.utm.edu) and Raymond Yates (rayjyate@ut.utm.edu). If you experience any lasting distress because of this survey, please contact Dr. Angie MacKewn (amackewn@utm.edu or 731-881-7370).   You must be legally considered an adult to participate in our research. If you are not the age of majority (18), you are not legally able to give consent on your own behalf. Please do not attempt to take this survey if you are under the legal age limit.   Although you are not receiving direct benefit from completing this survey, you will be aiding student researchers. If you wish to participate in this study, please continue and answer the following questions. Thank you for your time.

Word List 1

Fork	Ear	Cat	June	Gnat
Mirror	Marching	Apple	Lint	Foam
Carriage	Tree	Flash	Wild	Book
Black	Printer	Vehicle	House	Ditch

Word List 2

Wild	Cat	Lint	Carriage	Tree
Foam	Apple	Vehicle	Ditch	June
Gnat	Marching	Ear	Flash	Fork
House	Black	Mirror	Printer	Book

Distraction Phrase – Repetitively Written

"I am Sam Sam I am That Sam-I-am! That Sam-I-am! I do not like that Sam-I-am! Do you like green eggs and ham? I do not like them, Sam-I-am. I do not like green eggs and ham. Would you like them here or there? I would not like them here or there. I would not like them anywhere. I do not like green eggs and ham. I do not like them, Sam-I-am. Would you like them in a house? Would you like them with a mouse?"

Word List 3 – Selection Based

Cat Ditch Pilot Tree Bang Horseradish Marching Goofball

Apple Balcony Arrows Glitter Ear Book Internal Dense Mirror

Award Printer Lint